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NATIONAL DAM SAFETY PROGRAM. GREEN SWAMP NUMBER 4 DAM (NJ00212)--ETC(U)

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# 3 DAM

PASSAIC RIVER BASIN  
WANAQUE RIVER, PASSAIC COUNTY  
NEW JERSEY

LEVEL

# GREEN SWAMP NO.4 DAM

## PHASE I INSPECTION REPORT

### NATIONAL DAM SAFETY PROGRAM

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NJ 00212

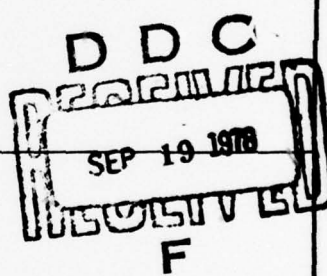
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DEPARTMENT OF THE ARMY  
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CUSTOM HOUSE - 2D & CHESTNUT STREETS  
PHILADELPHIA, PENNSYLVANIA 19106

AUGUST 1978

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report cites results of a technical investigation as to the dam's adequacy. The inspection and evaluation of the dam is as prescribed by the National Dam Inspection Act, Public Law 92-367. The technical investigation includes visual inspection, review of available design and construction records, and preliminary structural and hydraulic and hydrologic calculations, as applicable. An assessment of the dam's general condition is included in the report.		

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Honorable Brendan T. Byrne  
Governor of New Jersey  
Trenton, New Jersey 08621

31 AUG 1978

Dear Governor Byrne:

Inclosed is the Phase I Inspection Report for Green Swamp Dam No. 4 in Passaic County, New Jersey which has been prepared under authorization of the Dam Inspection Act, Public Law 92-367. A brief assessment of the dam's condition is given on the first three pages of the report.

Based on visual inspection, available records, calculations and past operational performance, Green Swamp Dam No. 4, a high hazard potential structure, is judged to be in good overall condition. This dam is a concrete saddle dike and is one of nine dams on Wanaque Reservoir. It has no spillway since overflow for the entire reservoir is handled by the Overflow Weir, 0.75 miles to the east of Green Swamp Dam No. 4. This dam is hydraulically adequate since it will not be overtopped by the Probable Maximum Flood (PMF). To insure the adequacy of the structure, the following actions, as a minimum, are recommended:

a. Within one year from the date of approval of this report, the following remedial actions should be taken:

(1) The crack along the dam top at the southeast corner of the Gate House should be repaired.

(2) The deteriorated gunite surfacing of the concrete should be replaced.

(3) The gunite surfacing over the expansion joints should be cut away from the expansion joints.

(4) The covers of the vertical drains should be freed and removed to allow inspection of both vertical and horizontal drains.

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Honorable Brendan T. Byrne

(5) Trees within 20 feet of the toe should be removed and replaced with suitable ground cover.

(6) The small impoundment area at the toe should be further checked for the source of water. Regular monitoring of the ponded water level with reference to the pool level should be initiated.

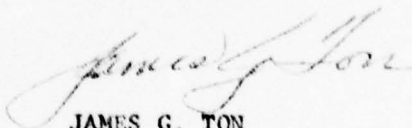
b. The drawdown capabilities of Overflow Weir (I.D. No. NJ00214) and Raymond Dam (I.D. No. NJ00213), which control water release for Wanaque Reservoir, should be increased. Increased drawdown capability will allow for lowering of the reservoir within an acceptable period of time to perform remedial work or for an emergency involving Green Swamp No. 4 Dam, or any other dam on the reservoir. This subject is addressed in the previously issued inspection reports for Overflow Weir and Raymond Dam.

A copy of the report is being furnished to Mr. Dirk C. Hofman, New Jersey Department of Environmental Protection, the designated State Office contact for this program. Within five days of the date of this letter, a copy will also be sent to Congressman Robert A. Roe of the Eighth District. Under the provisions of the Freedom of Information Act, the inspection report will be subject to release by this office, upon request, thirty days after the date of this letter.

Additional copies of this report may be obtained from the National Technical Information Services (NTIS), Springfield, Virginia, 22161 at a reasonable cost. Please allow four to six weeks from the date of this letter for NTIS to have copies of the report available.

An important aspect of the Dam Safety Program will be the implementation of the recommendations made as a result of the inspection. We accordingly request that we be advised of proposed actions taken by the State to implement our recommendations.

Sincerely yours,



JAMES G. TON  
Colonel, Corps of Engineers  
District Engineer

1 Incl  
As stated

Cy furn:  
Mr. Dirk C. Hofman, P.E.  
Department of Environmental Protection

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GREEN SWAMP DAM NO. 4 (NJ00212)

CORPS OF ENGINEERS ASSESSMENT OF GENERAL CONDITIONS

This dam was inspected on 24 and 25 May 1978 by Gilbert Associates, Inc. under contract to the State of New Jersey. The state, under agreement with the U. S. Army Engineer District, Philadelphia, had this inspection performed in accordance with the National Dam Inspection Act, Public Law 92-367.

Green Swamp Dam No. 4, a high hazard potential structure, is judged to be in good overall condition. This dam is a concrete saddle dike and is one of nine dams on Wanaque Reservoir. It has no spillway since overflow for the entire reservoir is handled by the Overflow Weir, 0.75-miles to the east of Green Swamp Dam No. 4. This dam is hydraulically adequate since it will not be overtopped by the Probable Maximum Flood (PMF). To insure the adequacy of the structure, the following actions, as a minimum, are recommended:

a. Within one year from the date of approval of this report, the following remedial actions should be taken:

(1) The crack along the dam top at the southeast corner of the Gate House should be repaired.

(2) The deteriorated gunite surfacing of the concrete should be replaced.

(3) The gunite surfacing over the expansion joints should be cut away from the expansion joints.

(4) The covers of the vertical drains should be freed and removed to allow inspection of both vertical and horizontal drains.

(5) Trees within 20 feet of the toe should be removed and replaced with suitable ground cover.

(6) The small impoundment area at the toe should be further checked for the source of water. Regular monitoring of the ponded water level with reference to the pool level be initiated.

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b. The drawdown capabilities of Overflow Weir (I.D. No. NJ00214) and Raymond Dam (I.D. No. NJ00213), which control water release for Wanaque Reservoir, should be increased. Increased drawdown capability will allow for lowering of the reservoir within an acceptable period of time to perform remedial work or for an emergency involving Green Swamp No. 4 Dam, or any other dam on the reservoir. This subject is addressed in the previously issued inspection reports for Overflow Weir and Raymond Dam.

APPROVED: James G. Ton

JAMES G. TON  
Colonel, Corps of Engineers  
District Engineer

DATE: 31 Aug 78

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PHASE I REPORT  
NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Green Swamp Dam No. 4
State:	New Jersey
County:	Passaic
U.S.G.S. Quadrangle Sheet:	Wanaque, N.J.
Coordinates:	Long. N. 41°02'25" Lat. E. 74°18'42"
Stream:	None (Off the Wanaque River)
Dates of Inventory:	24 May 1978

ASSESSMENT OF GENERAL CONDITION

The dam is in good condition as defined in Appendix I. No conditions requiring immediate drastic action were observed.

The 10-year old gunite surfacing has deteriorated at every expansion joint, and cracked in numerous places along the downstream slope. Some efflorescence is associated with the cracks. At the vertical expansion joint the gunite is buckled and cracked and whole sections of gunite have separated from the underlying concrete.

It is recommended that:

1. The crack along the dam top at the southeast corner of the Gate House be repaired.
2. The distressed gunite surfacing be repaired.
3. The gunite surfacing at the expansion joints be cut away from the joints.
4. The covers of the vertical drains be freed and removed to allow inspection of both vertical and horizontal drains.
5. The trees within 20 feet of the dam toe be removed.
6. The drawdown capability be increased.
7. The small impoundment area at the toe should be further checked for the source of water. Regular monitoring of the ponded water level with reference to the pool level should be initiated.





June 1978

OVERVIEW PHOTO - GREEN SWAMP 4  
(DOWNSTREAM VIEW OF DAM)

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1.0 PROJECT INFORMATION

1.1 GENERAL

1.2 Authority: Public Law 92-367, 8 August 1972, authorized the Secretary of the Army, through the U.S. Corps of Engineers to initiate a national program of safety inspections of non-Federal dams throughout the United States. Gilbert Associates, Inc. has entered into contract number DACW61-78-C-0114 with the Philadelphia Office of the U.S. Army Corps of Engineers to inspect this dam, Gilbert Work Order 06-7249-050.

1.1.2 Purpose of Inspection: The purpose is to conduct a Phase I inspection according to the U.S. Army Corps of Engineers Recommended Guidelines for Safety Inspection of Dams (Reference 1) and contract requirements between Gilbert Associates, Inc. and the Corps of Engineers. The objectives are to expeditiously identify whether this dam apparently poses an immediate threat to human life or property, and to recommend future studies and/or any obvious remedial actions that may be indicated by the inspection.

1.2 PROJECT DESCRIPTION

1.2.1 Dam and Appurtenances: Green Swamp Dam No. 4 is a concrete masonry gravity dam which extends 38 feet above original ground, 65 feet above final rock surface, and is 300 feet long. The dam crest is 11 feet wide. With the exception of the 72-inch gated pipe which is incorporated into the dam and delivers water to the Wanaque Reservoir from the Ramapo force main at selected time periods, there are no outlet provisions at this dam. Record drawing information is included at the end of this report. The water level is controlled at the Wanaque Overflow Weir (NJ 00214) which is a separate structure located 0.75 miles east of the dam.

Location: The dam is located 0.95 miles west of N.J. Route 511 in Wanaque, New Jersey and 2.2 miles north of Bloomingdale, New Jersey (see Figure 1). The location of the dam is also shown on the attached geologic map (Appendix F).

1.2.3 Size Classification: The dam is classified as a large structure because of its impoundment (73,960 acre-feet), in accordance with Section 2.1.1 of Reference 1.

1.2.4 Hazard Classification: The dam is located northwest of Wanaque and Haskell, New Jersey and upstream of a moderately populated flood plain (150 homes). The dam is classified as a high hazard potential based on the requirements of Section 2.1.2 of Reference 1.

1.2.5 Ownership: The dam is owned and maintained by the North Jersey District Water Supply Commission (NJDWSC), a New Jersey state commission. They have engineering and maintenance facilities located at Raymond Dam in Wanaque, N.J. The Chief Engineer of the NJDWSC in Wanaque is Mr. Dean C. Noll. The address is:

North Jersey District Water Supply Commission  
Ringwood Avenue  
Wanaque, N.J. 07465

1.2.6 Purpose of Dam: Green Swamp Dam No. 4 serves as a dam which closes off low topography in the rim of the Wanaque Reservoir. The reservoir supplies water to residents of Paterson, Passaic, Clifton, Montclair, Glen Ridge, Newark, Kearny and Bayonne, New Jersey.

1.2.7 Design and Construction History: This dam was constructed from May 24, 1925 to July 19, 1926 by Clifford F. MacEvoy Co., of Newark, New Jersey, as part of the total Wanaque Project. The Project began in 1920 and was completed with the reservoir being filled by March 4, 1929. The original design records could not be located by the staff of the NJDWSC at Wanaque. However, publications indicate the design was performed by employees of the NJDWSC with the assistance of individual consultants. The New Jersey Department of Environmental Protection (DEP) has monthly progress inspection reports and several photographs taken during construction. There is no indication of subsequent construction other than minor maintenance and the application of a gunite surface in 1967.

1.2.8 Normal Operational Procedures: Besides the gate controls and operation for the Ramapo force main, there is no operational procedure for this dam. It relies on adequate freeboard to contain floods in the reservoir, with overflow handled by the Overflow Weir (NJ 00214).

### 1.3 PERTINENT DATA

1.3.1 Drainage Area: 90.4 square miles

1.3.2 Discharge at Dam Site: Not Applicable

1.3.3 Elevation: (Feet above MSL)

Top of Dam - 312.0

Maximum Spillway Design Flood (SDF) Surcharge - 308.8 (See Section 5.0)

Full Flood Control Pool - Not Applicable

Recreation Pool - Not Applicable

Spillway Crest (gated) - Not Applicable

Upstream Portal Invert Diversion Tunnel - Not Applicable

Downstream Portal Invert Diversion Tunnel - Not Applicable

Streambed at Centerline of Dam - Not Applicable

Maximum Tailwater - Not Applicable

1.3.4      Reservoir:   Length of Maximum Pool - 6.1 miles

1.3.5      Storage (acre-feet):

Recreation Pool - Not Applicable  
Flood Control Pool - Not Applicable  
SDF Surcharge - 67,210  
Top of Dam - 73,960

1.3.6      Reservoir Surface (acres):

Top of Dam - 2,680  
SDF Surcharge - 2,590  
Flood Control Pool - Not Applicable  
Recreation Pool - Not Applicable  
Spillway Crest - Not Applicable

1.3.7      Dam:

Type - Concrete gravity  
Length - 300 feet  
Height - 38 feet (above surface), 65 feet (above foundation)  
Top Width - Top width is 10 feet below top coping. Coping on top of dam is 2.0 feet thick and 11 feet wide.  
Crest Elevation - 312 feet (MSL)  
Side Slope - Upstream vertical, downstream vertical, becoming 2 vertical to 1 horizontal  
Zoning - Not Applicable  
Impervious Core - Not Applicable  
Cut Off - None.  
Grout Curtain - Started below elevation 287 feet, minimum depth of curtain is 15 feet, maximum depth down to elevation 232± feet.

1.3.8      Diversion and Regulating Tunnel:   Not Applicable

1.3.9      Spillway:   Not Applicable

1.3.10     Regulatory Outlet:   Not Applicable

## 2.0 ENGINEERING DATA

### 2.1 DESIGN

A plan, profile, grouting record, and maximum section through the dam are shown on original record tracings which are on file at the NJDWSC engineering office (Mr. Dean C. Noll) at Wanaque, N.J. (See Figure 2). No original design data were available other than results mentioned in the North East Water Works Association publication (Reference 3) and a 1925 report (Reference 2) by the Commissioner of the NJDWSC.

### 2.2 CONSTRUCTION

A set of the record drawings showing plan, cross-sections, and profiles are available at the NJDWSC's office at Wanaque, N.J. A brief description of the construction of this dam, including foundation condition, appeared in the NJDWSC's 1925 report, pages 158-159 (Reference 2). The dam was constructed between May 24, 1925 and July 19, 1926.

### 2.3 OPERATION - Not Applicable

### 2.4 EVALUATION

2.4.1 Availability: Foundation exploration and design and construction data were not available, nor were structural and hydraulic design calculations. Reservoir water reading levels were available; also see paragraphs 2.1 and 2.2 above.

2.4.2 Adequacy: The record drawings supplemented by field data gathered on this inspection appear adequate for this Phase I safety inspection.

2.4.3 Validity: The record drawings appear to adequately represent the actual structure, based on the visual inspection.

### 3.0 VISUAL INSPECTION

#### 3.1 FINDINGS

3.1.1 General: The Phase I dam inspection was performed by a team of Gilbert Associates, Inc. engineers during May 24-25, 1978. A previous inspection of this dam was performed on April 5, 1977 by employees of the NJDWSC and is attached as Appendix E.

3.1.2 Dam: The dam is constructed as a concrete masonry gravity section. According to NJDWSC, the dam received a gunite surface in 1967. On the 2 vertical to 1 horizontal downstream slope, the surface is deteriorating badly. In all the vertical expansion joints the gunite has buckled and cracked. Numerous random cracks were noted over the face of the dam, some with efflorescence. In some locations, including several of the joint locations, the lower 2 to 3 feet of gunite surface has disappeared. The gunite seems to be separated from the concrete for the entire height that was physically inspected, approximately 8 feet.

According to the record drawing (sheet 45 in a set of 61) the five 8-inch lateral drains which drain the water from inside the dam should exit above grade. These drains are not visible; presumably they are buried under the granular material along the toe of the dam. A high water level was noted in this material.

The 72-inch Ramapo force main to the Wanaque Reservoir ends at Green Swamp Dam No. 4. This line is buried. Some ponded water was noted directly against the downstream toe, between this pipeline and the rock bluff forming the left abutment. This seems to be trapped water from springs existing at the rock face.

The top of the dam is reached via a structural steel stairway located on a mound of soil over the 72-inch force main.

The Gate House, located on the top, houses the gate valve operator; at the southwest outside corner of the Gate House a crack, about 15 inches long, 0.25 inches wide, and 1.75 inches deep was noted running to the adjacent expansion joint (see Appendix C).

The dam is positioned between two rock abutments with the left abutment steeply rising to elevation 400 feet, and the right gently rising to elevation 360 feet.

The contact between the abutment and the dam seems to be in good condition. The steep left abutment rock slope appears to be stable.

As observed, the rocks of the outcrops on both abutments consist of massive medium to coarse-grained granitic gneiss, which appear to be generally fresh-looking.

3.1.3 Appurtenant Structures: There are no appurtenant structures connected with the dam, other than the control building for the 72-inch Ramapo force main, located approximately 175 feet south of the dam.

3.1.4 Reservoir Area: The steep slopes along the reservoir rim near the dam site appear to be stable, and massive granitic gneiss outcrops are fully exposed along the shore. Adequate ground cover in the form of trees exists on the upper part of the left valley and along the west shore. Sediments derived from hillside erosion appear to be minimal.

3.1.5 Downstream Channel: There is no downstream channel at this dam; a parking area has been created level with the service road south of the dam.

### 3.2 EVALUATION

All the visual evidence, including the minor crack in the dam top at the Ramapo force main Gate House, deteriorating and cracked gunite surfacing, and lack of seepage and leakage at the faces and abutments of the dam have led to the conclusion that the dam is not in an imminently dangerous condition. Repairs to the gunite surfacing are required as well as grouting of the crack in the dam crest. At the expansion joints, the gunite should be chipped away to expose the joint. The trees growing within 20 feet of the dam toe should be removed.

### 3.3 ATTENDEES

#### North Jersey District Water Supply Commission

Marie DiLaura                      23 May, 1978

#### Gilbert Associates, Inc.

Rudolph J. Wahanik	23-24 May, 1978
Fine T. Hsu	23-24 May, 1978
Rudy P. Visser	23-24 May, 1978

#### 4.0 OPERATIONAL PROCEDURES

##### 4.1 PROCEDURES

The water level in Wanaque Reservoir is governed by the Overflow Weir structure, 0.75 miles east, to a pool elevation of 302.4 feet MSL. The highest water elevation recorded since October 1950 was 303.93 feet (References 6 and 7) with excess flow passing over the uncontrolled weir. There is no operational procedure at Green Swamp Dam No. 4 to control the water level or release water from the reservoir. The Ramapo force main discharges into the reservoir through a gate control house located at this dam and shown in the photographs of Appendix C. The Ramapo force main is a 72-inch diameter steel pipe line, 25,000 feet long that conveys pumped water from the Pompton Lake Dam in the Ramapo River. There is no pumping allowed during June through September. The system can deliver up to 100 MGD, depending on water needs and availability.

##### 4.2 MAINTENANCE OF DAM

The reservoir rim is traversed daily by NJDWSC guards who report apparent maintenance problems to the Chief Engineer. In addition, periodic inspections are made by engineers and/or other personnel of the NJDWSC and reports written regarding maintenance requirements. The 1977 inspection report (Appendix E) recommended repairing the loose gunite and insertion of tar at the expansion joints. This still remains to be done.

##### 4.3 MAINTENANCE OF OPERATING FACILITIES - Not Applicable

##### 4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

No automatic warning systems exist at this dam. A daily patrol is made by the NJDWSC security guards equipped with radios. According to NJDWSC personnel, the guards are instructed to radio the guard house, or failing that, to directly radio the Wanaque police of any obvious, impending hazard to residents from the dams on the Wanaque Reservoir.

##### 4.5 EVALUATION

The maintenance procedures for this dam are inadequate. Even though the gunite surfacing does not enhance the stability of the structure, it does protect the underlying concrete from spalling and should be kept in good repair. The concrete covers of the vertical drains should be freed and removed to in order to check functioning of both vertical and horizontal drains.

## 5.0 HYDRAULIC/HYDROLOGIC DESIGN

### 5.1 EVALUATION OF FEATURES

Other than the dam, there are no hydraulic structures or control facilities at this location, except for the Ramapo force main inlet. Reservoir overflow is provided by the Overflow Weir, 0.75 miles to the east. Details on the methodology used and the hydrologic results for this Report are presented in Appendix D.

5.1.1 Design Data: The maximum pool elevation for the design discharge of 18,000 cfs is 304.3 feet. This is based on the spillway elevation of 300.3 feet plus a head of 4.0 feet, for the Overflow Weir. With the flashboards in place, the overflow becomes a sharp edged weir with an elevation of 302.4 feet, and a pool elevation of 306.6 feet with the design flow of 18,000 cfs.

5.1.2 Experience Data: The maximum recorded reservoir level since October 1950 is 303.9 feet, 8.1 feet lower than the crest of Green Swamp Dam No. 4 which is at elevation 312.0 feet. This level was reached in March 1951 (References 6 and 7).

5.1.3 Visual Observations: There is no visual evidence to indicate the dam has ever been overtopped.

5.1.4 Overtopping Potential: The PMF, when developed as described in Appendix D and with the flashboards in place of the Overflow Weir, results in a reservoir elevation of 308.8 feet. One-half the PMF results in a reservoir elevation of 306.0 feet, with the flashboards in place. Since the top of the dam is at elevation 312.0 feet, it will not be overtopped by the PMF or one-half the PMF.

5.1.5 Reservoir Drawdown: The existing drawdown facilities installed in the several dams of the Wanaque Reservoir are not adequate to lower the water level of the reservoir in a short period of time. It is recommended that the owner design and construct water release structures that will allow lowering of the water level within an acceptable period of time.

A preliminary evaluation of the performance of the existing drawdown facilities is given in Appendix D. The time required to draw down the Green Swamp Dam No. 4 to the bottom surface level of 274 feet using the existing facilities at Raymond Dam is:

<u>System in Use</u>	<u>Time in Days</u>
Aerator System	120
36-inch Diameter Blowoff	377
Aerator and Blowoff	91

## 6.0 STRUCTURAL STABILITY

### 6.1 EVALUATION OF STRUCTURAL STABILITY

6.1.1 Visual Observations: The several damp spots observed on the downstream face of the dam do not appear to significantly affect the stability of the dam.

The 8-inch steel drains at each expansion joint were not observed, probably due to the placement of additional granular fill along the toe of the dam. The granular fill will aid in dissipating water and provides additional stability to the dam.

The crack on the dam crest at the Gate House is probably due to overstress in the concrete caused by the post-construction addition of the Gate House and equipment. It does not appear to be related to foundation instability.

Massive granitic gneiss is well exposed on both abutments.

6.1.2 Design and Construction Data: There are no design calculation data available at NJDWSC. Construction on this dam was started on May 24, 1925 and completed July 19, 1926. Reference 2 covers the Wanaque Project of which this dam was a part up to July 1925. Record drawing sheets 45, 46, and 48 in set 61 provide data on site topography, gravity section details, and grouting information.

According to Reference 2, "The concrete masonry gravity dam was designed to withstand the maximum static water pressure, uplift pressures, plus an assumed ice pressure exerted at the flow line of 20,000 pounds/linear foot."

Record drawing sheet 45 in a set of 61 indicates that the deepest part of the foundation excavation extends down to 27 feet below original ground giving the dam a maximum height of 67 feet. Competent ledge rock at this depth had been overlain by a boulder zone (Reference 2, page 164). Grouting was performed through 626 linear feet of drill hole using a total of 623 gallons of grout consisting of 47 bags of cement (Record drawing sheet 48 in a set of 61).

6.1.3 Operating Records: No distress of any kind was reported in data reviewed during the inspection.

6.1.4 Post-Construction Changes: The following deviations from the record drawing sheet 45 in a set of 61 were noted:

1. The open drains which were changed to blind drains in order to raise the grade along the toe of the dam.
2. The inclusion of the 72-inch force main in the dam, and the Gate House for the valve operator.
3. The addition of a structural steel stairway to gain access to the dam crest.

6.1.5 Stability Analysis: The stability analysis for this dam is based on the PMF water level and 100 percent uplift at the upstream toe. The calculation results indicate that the structure has an adequate factor of safety against sliding and overstressing; and it can be considered to have an adequate margin of safety with respect to overturning according to the screening criteria established by the Corps of Engineers (paragraph 4.4.4.4 of Reference 1). Therefore, the Green Swam No. 4 Dam is considered to be structurally stable. Details of forces involved and magnitude of the safety factors are given in Appendix H.

6.1.6 Seismic Stability: The dam is located within Zone 1 on the Algermissens Seismic Risk Map of the United States (1969 Edition). Calculations indicate the dam meets the screening criteria for having adequate safety factors against overturning, sliding and overstressing. Therefore, in accordance with page D-15 of Reference 1, it may be assumed to present no hazard from earthquake.

## 7.0 ASSESSMENT, RECOMMENDATIONS/REMEDIAL MEASURES

The assessment and remedial measures contained herein are based on the provisions of Appendix I, Conditions.

### 7.1 DAM ASSESSMENT

7.1.1 Safety: On the basis of the visual inspection and available record data, the dam does not exhibit any critical signs of distress such as structural cracking, severe differential settlement between the 30-foot sections, or horizontal alignment dislocation.

The dam top will not be overtopped by the PMF or one-half the PMF as discussed in Section 5.0. The addition of fill along the downstream toe of the dam has increased its stability against overturning.

7.1.2 Adequacy of Information: The visual inspection generally verifies the overall geometry of the dam as presented in the record drawings.

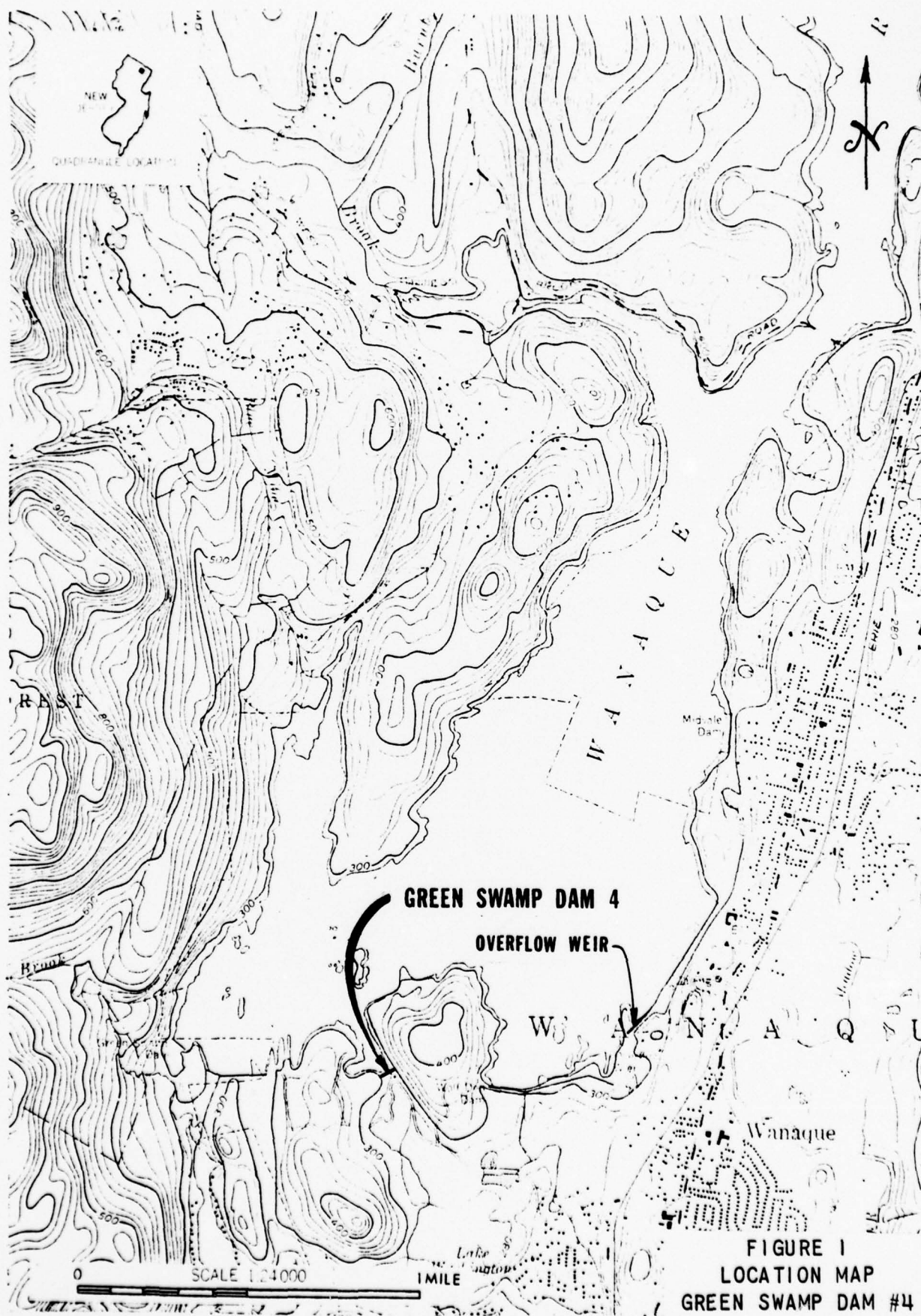
7.1.3 Urgency: Remedial measures recommended in paragraph 7.2 should be implemented as indicated.

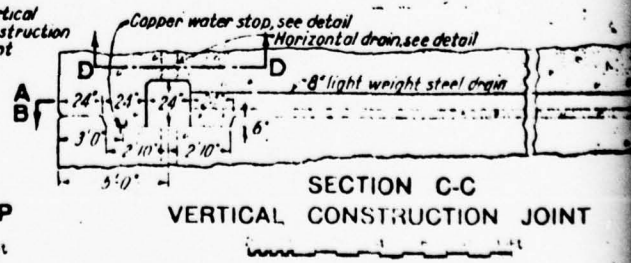
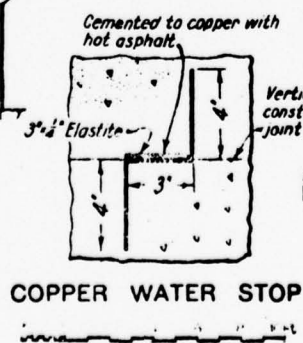
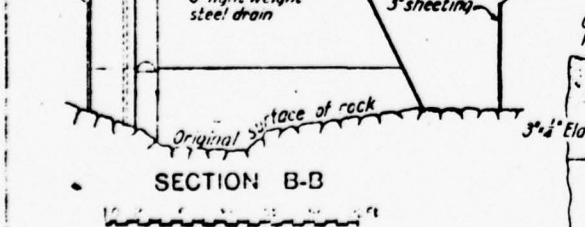
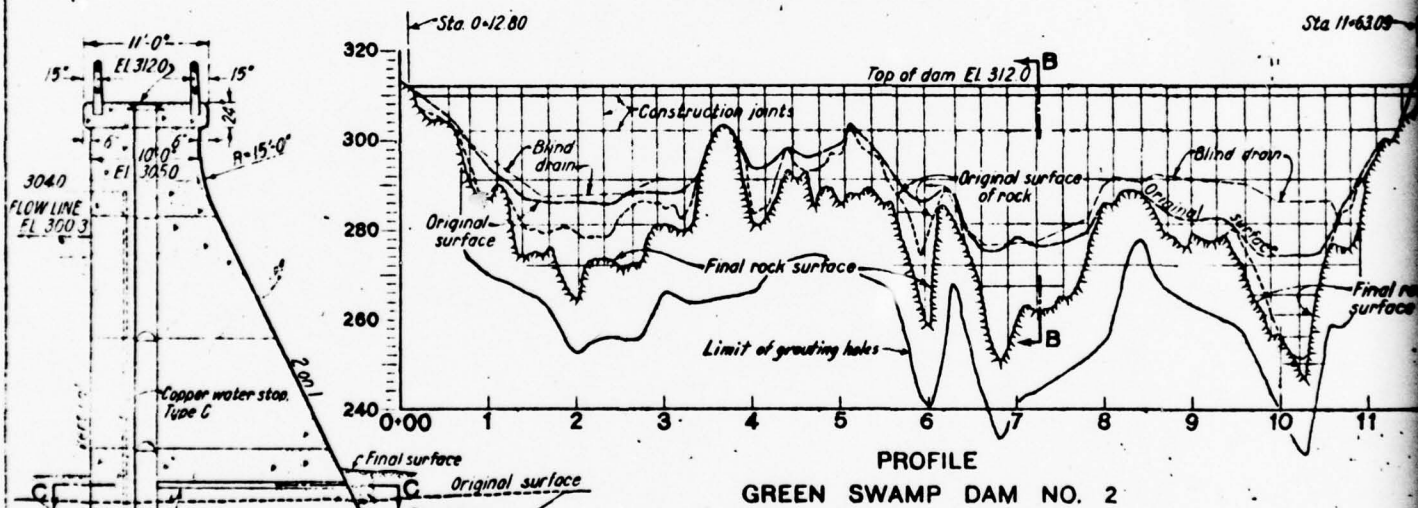
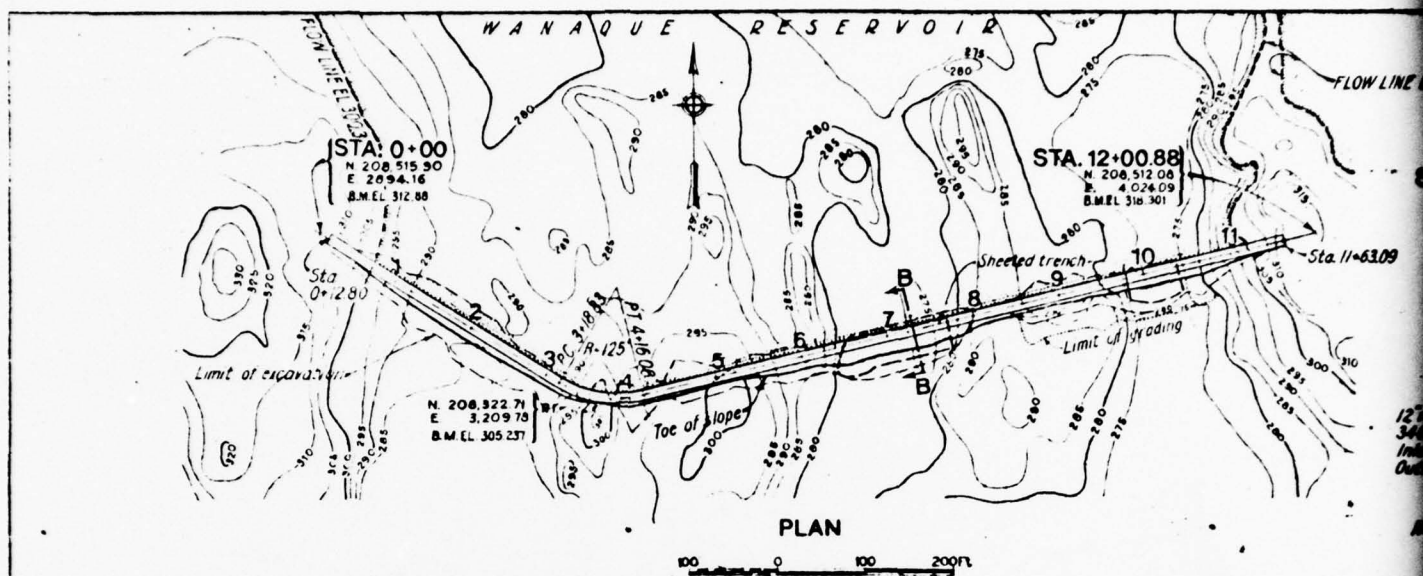
7.1.4 Necessity for Further Studies: None

### 7.2 RECOMMENDATIONS/REMEDIAL MEASURES

7.2.1 Recommendations: The following measures are recommended:

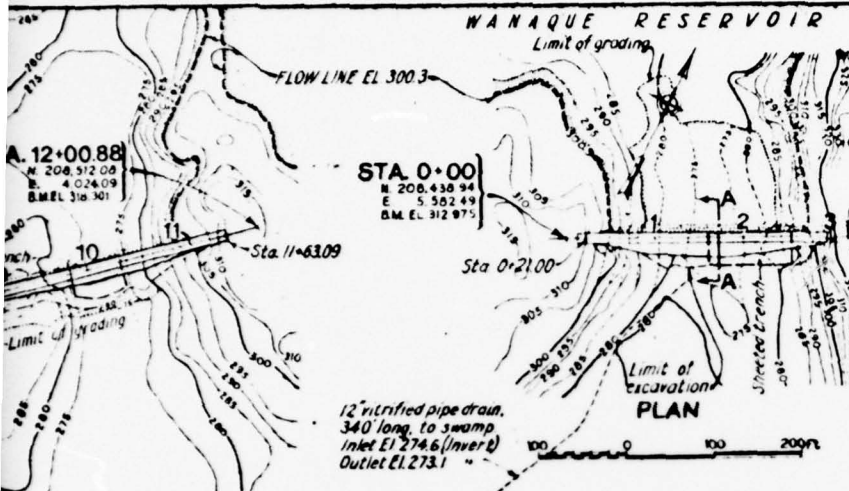
- a. The crack along the dam top at the southeast corner of the Gate House be repaired soon.
- b. The distressed gunite surfacing be repaired in the future.
- c. The gunite surfacing at the expansion joints be cut away from the joints.
- d. The concrete covers of the vertical drains be freed and removed to allow inspection of both vertical and horizontal drains.
- e. The Owner design and construct water release structures that will allow lowering of the water level within an acceptable period of time.
- f. The small impoundment area at the bottom of the left abutment against the downstream toe be further checked soon for the source of water by means of pumping. Regular monitoring of the ponded water level with reference to the pool level will also help determine the cause of ponding. The result shall be evaluated by a qualified geotechnical engineer.



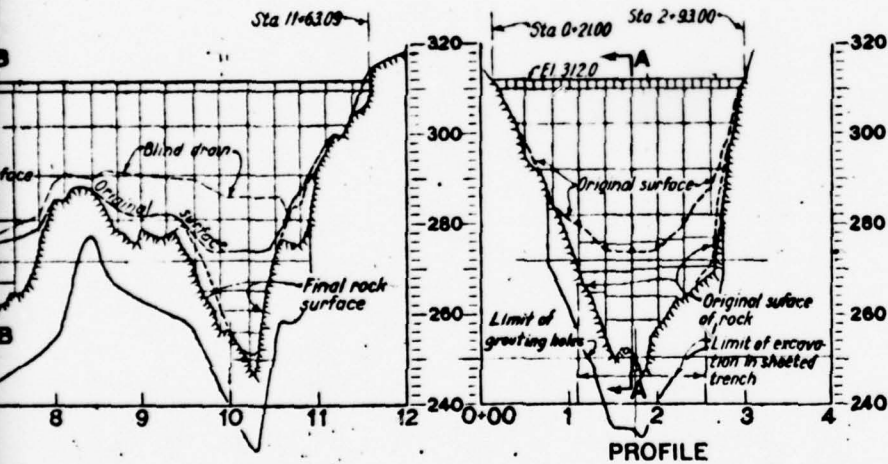
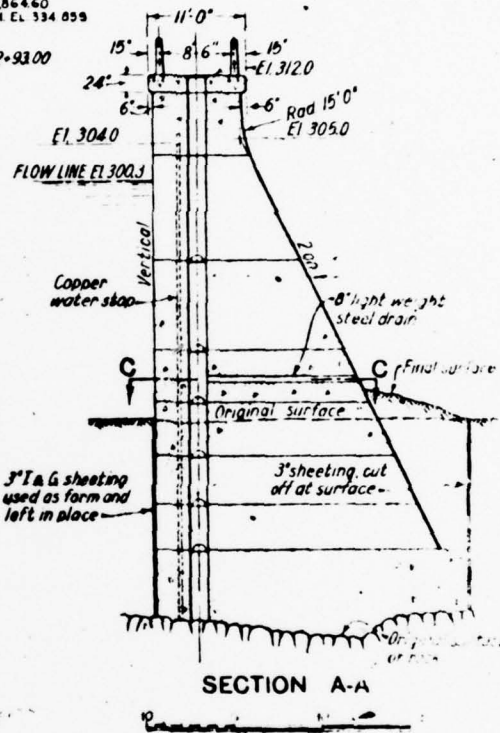


DETAILS COM

RECORD DRAWING  
SHEET 45 SHEETS IN SET 61



NOTE - Bench marks are 1" brass rods caulked into ledge rock



# GREEN SWAMP DAM NO. 4

## CONSTRUCTION RECORD

Dam No 2 built July 5, 1924 to Nov 16, 1925.  
Dam No 4 built May 24, 1925 to July 19, 1926  
under Contract 7, Clifford F. MacEvoy Co.,  
Newark, N.J., Contractor, in accordance with  
this record drawing

Engineer in charge  
NORTH JERSEY DISTRICT  
WATER SUPPLY COMMISSION

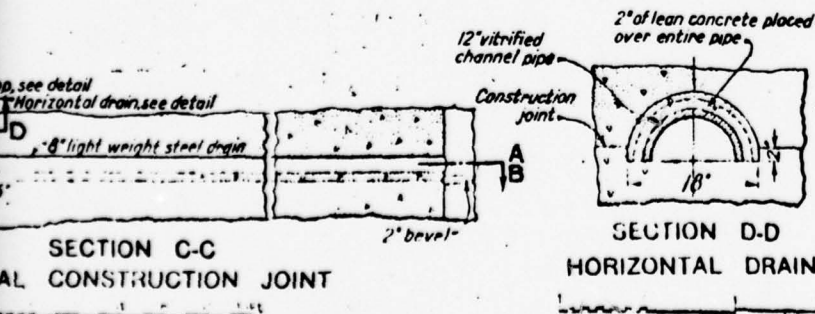
## WANAQUE RESERVOIR GREEN SWAMP DAMS NOS. 2 AND 4 PLANS, PROFILES AND SECTIONS

DETAILS COMMON TO BOTH DAMS

*Paul C. MacEvoy*  
Asst. Chief Engineer

APRIL 30, 1931

FIGURE 2



APPENDIX A  
VISUAL CHECKLIST

Check List  
Visual Inspection  
Phase I

Name Dam: Green Swamp Dam No. 4 County: Passaic State: New Jersey Coordinators: Philadelphia District  
Corps of Engineers

Date(s) Inspection: May 23, 1978  
May 24, 1978

Weather: Sunny and Dry Temperature: 76°F (air)

Pool Elevation at Time of Inspection: 302.7 m.s.l.

Tailwater at Time of Inspection: Not Applicable

Gilbert Associates, Inc.  
Inspection Personnel:

Other:

Rudolph J. Wahanik  
Fine Hsu  
Rudy P. Visser

Marie Di Laura - North Jersey District Water Supply  
Commission

Rudolph J. Wahanik - Recorder

Dam Type: It is a gravity dam of concrete masonry with a 2 vertical:1 horizontal downstream slope. The dam is used as a water retaining structure and is one of the nine dams that form Lake Wanaque.

Crest Elevation - 312 feet

Crest Width - 11 feet

Dam Length - 300 feet

Spillway Location: The reservoir spillway is located 0.75 miles away from Green Swamp Dam No. 4 and a separate inspection report has been prepared for the spillway.

# CONCRETE DAMS

Sheet 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SEEPAGE OR LEAKAGE	A small pool of water was found between the 72-inch force main, the toe of the left rock abutment and the toe of the dam.	Probably trapped water from springs in abutment and rain water.
STRUCTURE TO ABUTMENT JUNCTIONS	The connection between the abutments and dam is dry and in good condition without any signs of past or recent leakage. The rock abutment slopes appear to be stable.	
DRAINS	The dam is provided with five 8-inch diameter drain pipes placed below the downstream grade. No seepage flow could be visually detected. Each of the drain pipes is connected to a 24-inch x 24-inch manhole. Two of the vertical manhole shafts were slated to be opened; all efforts to open same failed.	The 12-inch vitrified buried pipe drain, 340 feet long, connected to the swamp as shown on the record drawing, could not be inspected.
WATER PASSAGES	Besides the 8-inch diameter drains described above, this dam does not have any specific passages to discharge water because it is used as a water retention structure. A 72-inch reinforced concrete force main enters the structure at a few feet below ground surface.	Ramapo force main from Pompton Lakes Dam on the Ramapo River.

# CONCRETE DAMS

Sheet 2

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
FOUNDATION	<p>Rock outcrops on both abutments consist of massive, medium to coarse grained granitic gneiss which appears to be competent enough to support the concrete dam structure, provided the same type and quality of rock exist in the foundation area.</p>	<p>Granular fills were placed in the low area along the toe.</p>
SURFACE CRACKS CONCRETE SURFACES	<p>The exposed dam surfaces were gunited in 1967. The gunited surface is extensively cracked along the crest and the downstream surface of the dam. There are some vines growing along the downstream face and approximately 45% of the gunited surface is loose. The exposed surface is starting to deteriorate but no remedial action is recommended at this time, except for replacing the loose gunite.</p>	
STRUCTURAL CRACKING	<p>A crack, 15 inches long, 1/4 inch wide, 1-3/4 inches deep runs from the southeast corner of the Gate House to the closest expansion joint.</p>	<p>Could be due to addition of Gate House, etc., to top of dam.</p>
VERTICAL AND HORIZONTAL ALIGNMENT	<p>The vertical and horizontal alignment follows the original design drawings.</p>	
MONOLITH JOINTS	<p>Not Applicable</p>	
CONSTRUCTION JOINTS	<p>Besides some small areas where a few moist whitish exudations exist along the downstream surface, no leakage or apparent displacement of the construction joints could be observed.</p>	
OTHER		

# CONCRETE DAMS

Sheet 3

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONSTRUCTION JOINTS	Besides one small wet area along the downstream surface, no leakage or apparent displacement of the construction joints could be observed.	

OTHER

# EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	Not Applicable	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	Not Applicable	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	Not Applicable	
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Not Applicable	
RIPRAP FAILURES	Not Applicable	
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Not Applicable	
ANY NOTICEABLE SEEPAGE	Not Applicable	
STAFF GAGE AND RECORDER	Not Applicable	
DRAINS	Not Applicable	

OUTLET WORKS  
(NONE AT GREEN SWAMP DAM NO. 4)

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	Not Applicable	
INTAKE STRUCTURE	Not Applicable	
OUTLET STRUCTURE	Not Applicable	
OUTLET CHANNEL	Not Applicable	
EMERGENCY GATE	Not Applicable	

UNGATED SPILLWAY  
(NONE AT GREEN SWAMP DAM NO. 4)

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	Not Applicable	
APPROACH CHANNEL	Not Applicable	
DISCHARGE CHANNEL	Not Applicable	
BRIDGE AND PIERS	Not Applicable	

GATED SPILLWAY  
(NONE AT GREEN SWAMP DAM NO. 4)

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL	Not Applicable	
APPROACH CHANNEL	Not Applicable	
DISCHARGE CHANNEL	Not Applicable	
BRIDGE AND PIERS	Not Applicable	
GATES AND OPERATION EQUIPMENT	Not Applicable	

# INSTRUMENTATION

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None Observed	
OBSERVATION WELLS	None Observed	
WEIRS	None Observed	
PIEZOMETERS	None Observed	
OTHER		

# RESERVOIR

## REMARKS OR RECOMMENDATIONS

## OBSERVATIONS

## VISUAL EXAMINATION OF

### SLOPES

A continuous high and steep rock slope is distributed along the left abutment and nearby reservoir rim, which appears to be in a stable condition. At the lower part of the reservoir slope a sheer cliff with occasional tree growth along the rock fractures exists. Along the right abutment and nearby reservoir rim, a gentle rock slope is also stable.

### SEDIMENTATION

Because of rocky terrain and good ground cover, little sediments are expected to be deposited in the reservoir from the shore area adjacent to the dam.

# DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	The area downstream of the dam is heavily wooded. There is no downstream channel.	
SLOPES	The longitudinal slope between the dam and Lake Washington appears to be 1.5 percent.	
APPROXIMATE NO. OF HOMES AND POPULATION	About 268 homes are located downstream of the dam within a 1 mile radius with an estimated population of 900.	

APPENDIX B

ENGINEERING DATA CHECKLISTS

## APPENDIX B

### Check List Engineering Data Design, Construction, Operation

ITEM	REMARKS
PLAN OF DAM	Detailed construction drawing exists, see following drawing of Case C, Dr. 12: File 3.43 Wa, Acc. 3245 (Plans) (2 and 4) Profiles and Sections for Dams 2 and 4.
REGIONAL VICINITY MAP	USGS Wanaque, N.J. Quadrangle, photorevised 1971.
CONSTRUCTION HISTORY	A report was published in 1925 and contains a detailed account of the construction procedure used and of some of the foundation problems encountered.
TYPICAL SECTIONS OF DAM	Drawing Case C, Dr. 12; File 3.43, Acc. 3242 shows miscellaneous profiles, Dams 2 and 4. Case C, Dr. 12; File 3.42 Wg, Acc. 3248 shows grouting records for Green Swamp Dams Nos. 2 and 4.
HYDROLOGIC/HYDRAULIC DATA	There are continuous records since 1919. The USGS maintains a gaging station downstream of Wanaque Reservoir station 91387000 Wanaque River at Wanaque, N.J.
OUTLETS - PLAN	Not Applicable - This dam is a water retention structure that together with eight other dams forms Lake Wanaque.
- DETAILS	
- CONSTRAINTS	
- DISCHARGE RATINGS	

# APPENDIX B

## Check List Engineering Data Design, Construction, Operation

ITEM	REMARKS
RAINFALL/RESERVOIR RECORDS	There are continuous records since 1892.
DESIGN REPORTS	A brief description of the design criteria used in the design of this dam is shown in pages 52 thru 56 of the Wanaque water supply report published in July 1925 by the North Jersey District Water Supply Commission of the State of New Jersey.
GEOLOGY REPORTS	See Page 54 of July 1925 Report.
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	Besides the description of the July 1925 Report, no specific calculation sheets or descriptions of the results are known to exist. Volume of material used in dams as a function of height, is shown in Case C, Dr. 11 File 43.43, Acc. 1128.
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	Although detail boring records for the dam could not be found, borings were probably made because pages 54 and 55 of the July 1925 report says: "Consideration of foundation conditions and the quantity of material available resulted in the selection of the masonry type dam for sites Nos. 2 and 4 where ledge rock is near the surface and embankment material of difficult access."
POST-CONSTRUCTION SURVEYS OF DAM	See report of July 1925 for account of construction of the dam.

# APPENDIX B

## Check List Engineering Data Design, Construction, Operation

ITEM	REMARKS
BORROW SOURCES	See page 106 of July 1925 report. Case C, Dr. 2, File 3.43, Acc. 673 and Case C, Dr. 1, File 3.42, Acc. 182, 211, 227, 228 and 331. These are for the materials used in the nine dams.
SPILLWAY PLAN	Not required because of the nature of the dam.
SECTIONS	
DETAILS	
OPERATING EQUIPMENT PLANS & DETAILS	Not required because of the nature of the dam.
MONITORING SYSTEMS	None
MODIFICATIONS	The lateral drains were buried by placing granular fill along the toe of slope - a 72-inch force main and Gate House were incorporated in the dam - instruction of a structural steel stairway - guniting of dam in 1967.
HIGH POOL RECORDS	Daily water level records available. Maximum pool elevation - 303.93, March 31, 1951.

APPENDIX B

Check List  
Engineering Data  
Design, Construction, Operation

ITEM	REMARKS
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	For Inspection Reports dated 3/20/28 and 4/5/77 see Appendix E.
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None
MAINTENANCE OPERATION RECORDS	Available in NJDWSC

## APPENDIX B

### Check List Engineering Data Hydrologic and Hydraulic Data

DRAINAGE AREA CHARACTERISTICS: Densely forested, few homes, very hilly with minimal cover on bedrock.

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 302.4 (53240 Acre-feet)

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): Not Applicable

ELEVATION MAXIMUM SPILLWAY DESIGN FLOOD POOL: 308.8

ELEVATION TOP OF DAM: 312.00

CREST: 2.0-foot thick concrete coping, 11 feet wide with handrails

- a. Elevation: 312
- b. Type: Non-overflow
- c. Width: 11 feet
- d. Length: 300 feet
- e. Location Spillover: Not Applicable
- f. Number and Type of Gates: Not Applicable

#### OUTLET WORKS:

- a. Type: Not Applicable
- b. Location: Not Applicable
- c. Entrance Inverts: Not Applicable
- d. Exit Inverts: Not Applicable
- e. Emergency Drawdown Facilities: Not Applicable

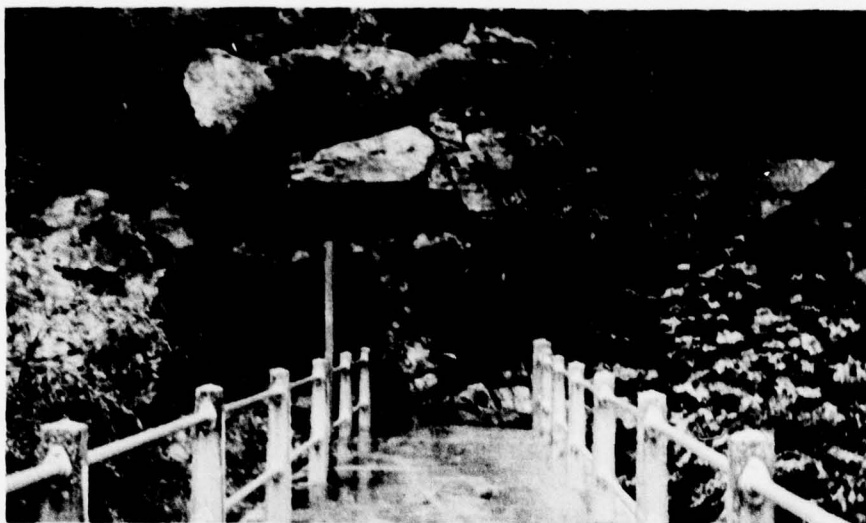
#### HYDROMETEOROLOGICAL GAGES:

- a. Type: Rainfall recording chart, 24-hour precipitation can, and maximum and minimum temperature recorder. Float type continuous stream level recorder with drum chart.
- b. Location: Raymond Dam in Wanaque, New Jersey.
- c. Records: Weather data published as climatological Data-Wanaque-Raymond Dam by the National Oceanic and Atmospheric Administration. Stream flow data is recorded by the USGS.

MAXIMUM NON-DAMAGING DISCHARGE: Non-overflow dam.

APPENDIX C

PHOTOGRAPHS



June 1978

LEFT ABUTMENT



June 1978

UPSTREAM VIEW

APPENDIX D

HYDRAULIC AND HYDROLOGIC COMPUTATIONS

APPENDIX E  
PREVIOUS INSPECTION REPORTS

NORTH JERSEY DISTRICT WATER SUPPLY COMMISSION

M E M O R A N D U M

TO: Dam Inspection File

FROM: Joseph Foley, Engineer

DATE: April 5, 1977

On March 31, 1977 Roscoe Jennings, Doug De Lorie and I inspected the dams at the Wanaque Reservoir; the following is a report on their conditions and recommendations on maintenance of same.

FURNACE ROAD DAM

Condition: There are trees and brush on the wet and dry sides of the dam and also a small swamp of apparently trapped water behind the dam.

Recommendations: The trees should be killed and removed using poison suitable for potable water.

MIDVALE DAM

Condition: Some trees are growing on the wet and dry sides of the dam. There is a small spring flowing from the foot of the dam at the north end. Wet spots and soft wet sand are also apparent at the foot of the dam. No sink holes or other indications of dam failure were apparent at this location. A sample of water from this spring and a sample from the reservoir were taken and analyzed, the results are as follows:

Spring Water:	Specific conductivity	68
	pH	6.3

Reservoir Water:	Specific conductivity	102
	pH	6.9

The results indicate that this water is more likely to be ground water than reservoir water. (For additional information, please refer to a memo from Bob Wieland to George Destito dated May 3, 1976).

Recommendations: The trees on the dam should be killed and removed. The dam should also be checked periodically to be sure the spring is not a leak in the dam.

RAYMOND DAM

Condition: Excellent

SPILLWAY

Condition: Good, except that it was indicated by Ernie Restaino that there is a small leak in the spillway. I did not observe it because of the overflow. I will check it again when the reservoir goes down.

Recommendations: The leak in the spillway should be fixed when the reservoir goes down.

WOLF DEN DAM

Condition: There are trees and shrubs on both the wet and dry sides. There are small springs flowing from the low sections behind the dam. Some samples were also taken here and the results were that the water had a specific conductivity of 90 and a pH of 6.3, so this water is most likely ground water also.

Recommendations: I recommend that the trees and shrubs be removed.

GREEN SWAMP

#4 Dam

Condition: The general condition of the dam is good, although sections of the gunite surfacing are cracked and have fallen off (especially near the expansion joints), due to moisture that found its way under the gunite. There was water running out of the drain but this flow was not excessive.

Recommendations: The cracked and loose gunite should be chipped away and replaced and at the expansion joints, the gunite should be chipped and tar poured in to allow expansion of the concrete.

#3 and #2A Dams

Condition: Both small dams are heavily wooded and there is a small swamp behind the #3 dam.

Recommendations: The only recommendation for these dams is that the trees be removed from both sides of the dams.

#2 Dam

Condition: This dam is in excellent condition, except around the expansion joints where the gunite is cracked due to the fact that no allowance was made for expansion when the guite was applied to the dam. There is also a swamp behind this dam, but this looks like a natural swamp.

Recommendations: The gunite at the expansion joints should be chipped away and tar poured in to allow expansion and any other cracks in the gunite should be chipped and repaired.

#1 Dam

Condition: There are trees and shrubs on both wet and dry sides of this dam. There is also a swamp behind the dam.

Recommendations: The dam should be cleared of trees and shrubs.

As a result of my research, so far on dam inspection, I received a booklet, "Supervision of Dams by State Authorities" published by the United States Committee on large dams, July 1966. This publication had little information on the actual inspection of dams but it did have some useful information such as: the function of dam supervision in New Jersey is performed by the Chief Engineer, Division of Water Policy and Supply, Department of Conservation and Economic development. Inspection of dams is done by the State at the State's own expense on the complaint of potential failure.

Additional information on dam inspection is also coming from the Corps of Engineers and the United States Committee on Large Dams.

JF:lk

cc: Dean C. Noll  
Robert G. Wieland

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FROM COPY FURNISHED TO DDC

Report on Dam Inspection

MANAQUE PROJECT

Application No. 32.

Location 23.31.6.4.9 and nearby.

On March 23, 1928, the gates in the main dam were closed except for the passage of 27 m. g. d. through the blow-off, and on March 29, 1928, the water in the reservoir had risen 7 feet.

On March 29, 1928, in company with Mr. H. T. Critchlow, inspection was made of all of the dams in the Manaque project.

Furnace Road dam was found to be about 50 per cent complete.

Post Rock Diversion dam, weir and control house were complete except for closing a small breach which was left in the dam for stream control, and installation of recording gage in the control house.

Manaque Main dam.

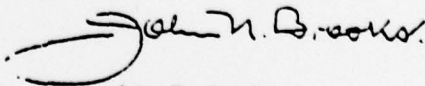
Midvale Dam.

Overflow Weir.

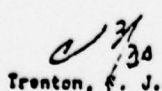
Wolf Den Dam, and

Green Swamp Dams Nos. 1, 2, 3 and 4 were complete and were given final inspection.

The construction of all dams has been done in accordance with the approved plans and in a thoroughly workmanlike and satisfactory manner.



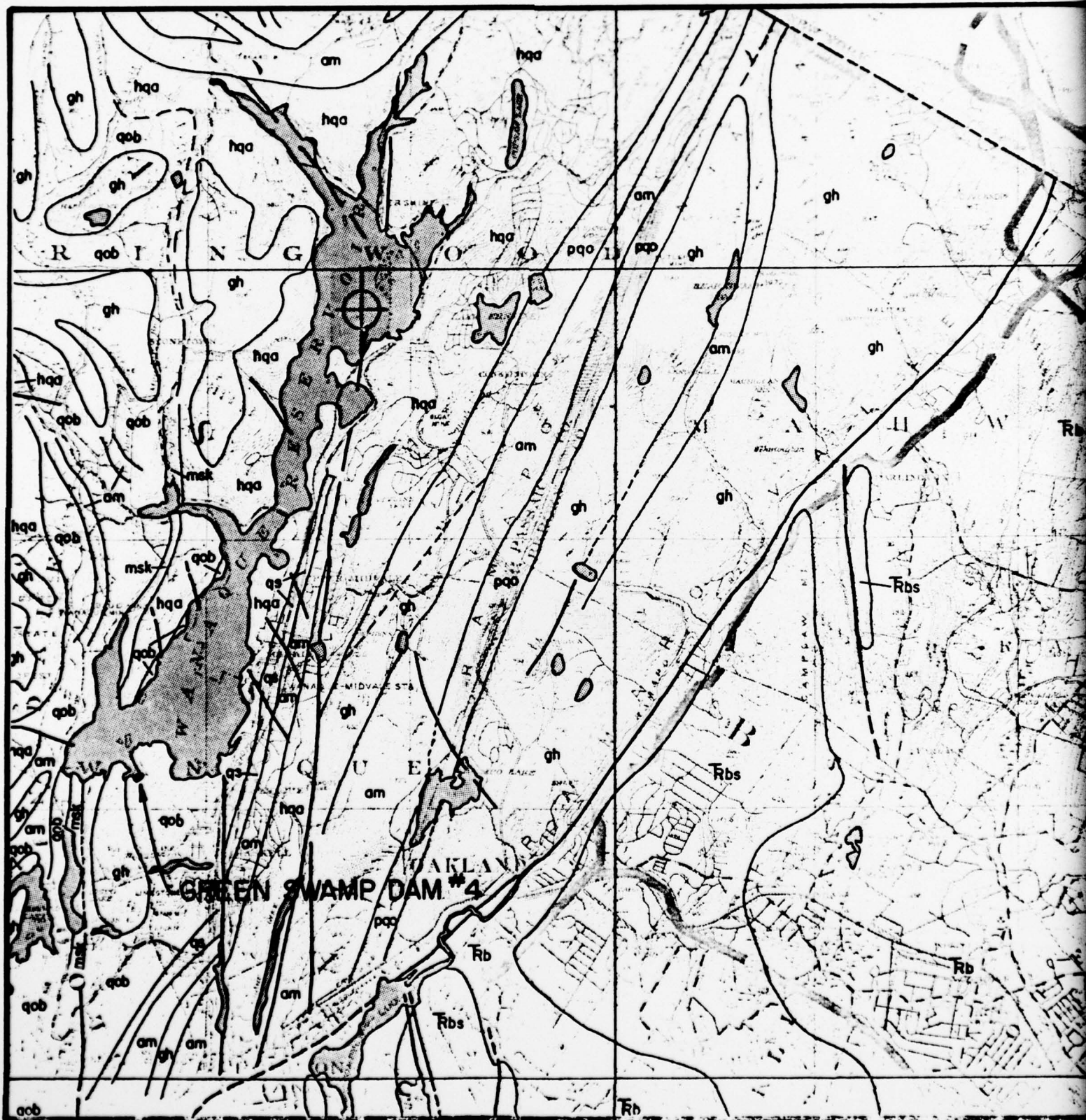
John H. Brooks  
Hydraulic Engineer.

  
Trenton, N. J.

March 30, 1928.

(New Jersey - Dept. of Environmental Protection)

APPENDIX F  
REGIONAL GEOLOGIC MAP





## LEGEND

### TRIASSIC

T<sub>b</sub> BRUNSWICK FORMATION  
R<sub>bs</sub> BASALT FLOWS

### PRECAMBRIAN

gh MOSTLY HORNBLENDE GRANITE AND GRANITE GNEISS  
am AMPHIBOLITE  
pqo PYROXENE GNEISS; MAINLY QUARTZ-OLIGOCLASE -  
CLINOPYROXENE GNEISS  
hqa PYROXENE GNEISS; MAINLY QUARTZ-ANDESINE GNEISS  
WITH BOTH ORTHO-AND CLINOPYROXENE  
qo QUARTZ-OLIGOCLASE-GNEISS  
qob QUARTZ-OLIGOCLASE-BIOTITE GNEISS  
qs SILLIMANITE GNEISS  
msk MARBLE AND SKARN

— CONTACT LINE  
— FAULT LINE

### NOTES:

1. THE PRECAMBRIAN MAP UNITS REPRESENT GENERALIZED GROUPINGS OF ROCK TYPES BASED MAINLY ON MINERAL COMPOSITION. THERE IS MUCH LOCAL VARIATION IN THE MINERAL COMPOSITION.
2. THE CONTACT LINES AND FAULT LINE SHOWN ON THE DRAWING ARE DASHED WHERE INFERRED.

### SOURCE:

NEW JERSEY GEOLOGICAL SURVEY TOPOGRAPHIC SERIES  
AND GEOLOGIC OVERLAY SHEETS 23.



## APPENDIX F REGIONAL GEOLOGIC MAP SHOWING DAM LOCATION

APPENDIX G

REFERENCES

## APPENDIX G

### REFERENCES

1. Recommended Guidelines for Safety Inspection of Dams, Appendix D, (Washington, D.C., Department of the Army, Office of the Chief of Engineers).
2. North Jersey District Water Supply Commission - Report 1925, (Newark, N.J., Office of the Commission), 1925.
3. Public Works, Vol. 54, No. 5, May 1923.
4. Water Resources Data for New Jersey, Part 1, Surface Water Records, United States Department of the Interior, Geologic Survey.
5. HEC-1 Flood Hydrograph Package, Hydrologic Engineering Center, Corps of Engineers, January, 1973.
6. Daily Reservoir Water Level and Discharge Record Files from October 1950 to date, owned by the NJDWSC.
7. Water Resources Data for New Jersey, Part 1, Surface Water Records, USGS, Department of the Interior.
8. Passaic River Basin - New Jersey and New York Survey Report for Water Resources, New York District Corps of Engineers, June 1972.

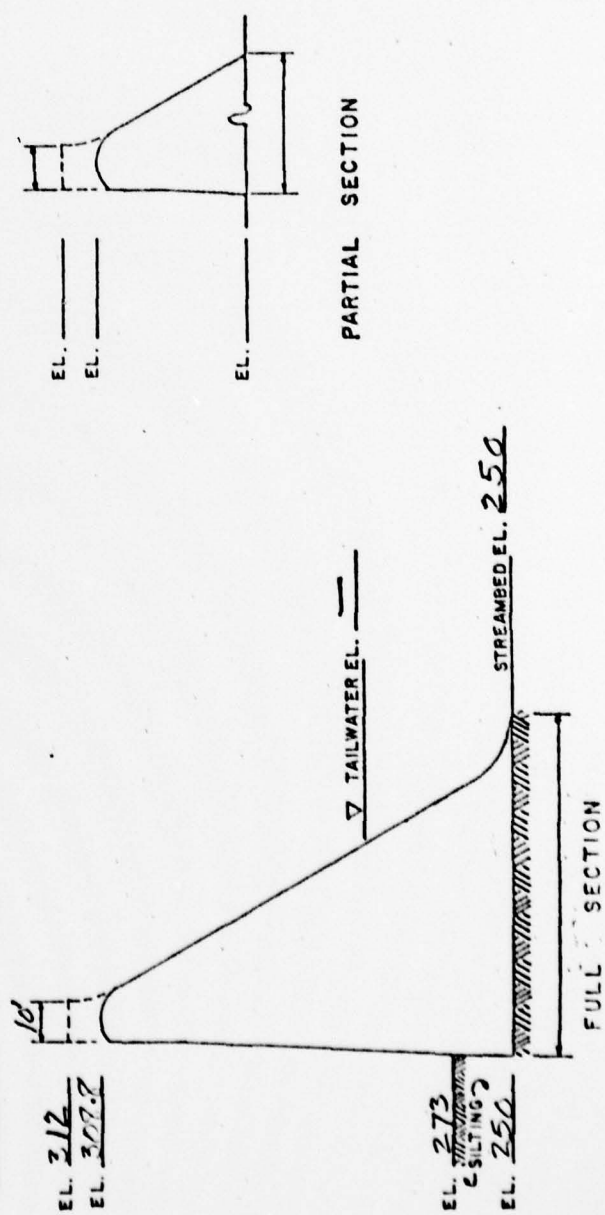
APPENDIX H

STABILITY ANALYSIS

# GRAVITY DAM DESIGN STABILITY ANALYSIS

ANALYSIS DONE ON X FULL SECTION — PARTIAL SECTION  
LOCATION OF SECTION GREEN SWAMP DAM #4 (Sta. 1+75)  
ANALYSIS PREPARED BY R.F. Nell

LOADING CASE	ELEV. HEAD WATER	ELEV. TAIL WATER	Σ V	Σ H	Σ M EV	LOCATION RESULTANT FROM TOE	% BASE IN COMPRESSION	FACTOR SAFETY SLIDING	FOUNDATION PRESSURE	
									TOE KSF	HEEL KSF
PROBABLE MAX. FLOOD	309.8	—	137 1/4	108 1/4	0.79	9.18'	73	51.1	9.95	0



Page 15  
Eng. Mark  
7/10/78  
Reviewed J. B. Burchard  
7/20/78

APPENDIX I

CONDITIONS

## APPENDIX I

### CONDITIONS

This report is based on a visual inspection of the dam, a review of available engineering data, and a hydrologic analysis performed during Phase I Investigation as set forth in the Recommended Guidelines for Safety Inspection of Dams, as modified by the contract between the U.S. Corps of Engineers and Gilbert Associates, Inc., Contract No. DACW61-78-C-0114.

The foregoing review, inspection, and analysis are by their nature limited in scope. It is possible that hazardous conditions exist and that conditions exist which with time might develop into safety hazards and that these conditions are not detectable by means of the aforesaid review, inspection, and analysis. Accordingly Gilbert Associates, Inc. cannot and does not warrant or represent that conditions which are hazardous do not exist, or that conditions do not exist which with time might develop into safety hazards.

As required by the Corps of Engineers the terms "good", "fair", "poor", "condition" have been used in this report to characterize the information obtained from the aforesaid review, inspection, and analysis.

The definitions of these terms as used are:

- "good condition" - minor studies or remedial measures are required.
- "fair condition" - sizeable studies or remedial measures are required due to deficiencies which could be hazardous depending on conditions. Immediate attention is required.
- "poor condition" - major studies or remedial measures are required due to deficiencies which could be hazardous depending on conditions. Immediate studies or corrective action is required.